CHAPTER 1. INTRODUCTION AND BACKGROUND

A. The Importance of Long-term Monitoring

In 1992, the National Academy of Sciences (1992) reviewed the natural resources management program of the National Park Service (NPS) and concluded, "if this agency is to meet the scientific and resource management challenges of the twenty-first century, a fundamental metamorphosis must occur." Indeed, that metamorphosis materialized when the National Park Service implemented a strategy to standardize inventories and monitoring of natural resources on a programmatic basis throughout the agency. The effort was undertaken to ensure that the approximately 270 park units with significant natural resources possess the resource information needed for effective, science-based managerial decision-making and resource protection. The national strategy consists of a Framework for National Park Service Inventory and Monitoring having three major components:

completion of basic natural resource inventories in support of future monitoring efforts;
creation of experimental Prototype Monitoring Programs to evaluate alternative monitoring designs and strategies; and
implementation of operational Vital Signs monitoring in all natural resource parks.

A fundamental goal of the National Park Service is to protect or maintain natural ecosystem structure and function in National Parklands. Alaskan National Park units are among the last remaining wilderness areas of the world - large enough to allow ecological processes and wildlife populations to fluctuate and biological diversity to evolve and adapt naturally. These large National Parks have been viewed as "ecological baseline controls" that provide us with unique insights into the functioning of ecosystems in which the effects of humans are minimized (Arcese and Sinclair 1997).

Knowing the condition of natural resources in national parks is crucial to the Service's ability to protect and manage parks. National Park managers across the country are confronted with increasingly complex and challenging issues, and managers are increasingly being asked to provide scientifically credible data to defend management actions. Many of the threats to park resources, such as invasive species and air and water pollution, come from outside of the park boundaries, requiring a landscape approach and integrated long-term monitoring to understand and protect the park's natural resources.

> *"And so we might continue to ask questions, the answers to which would be sought by National Park Service scientists were there a formal, continuing, and sufficiently massive program of ecological and systematic monitoring." (Cain 1959)*

In this plan, we define integrated monitoring as 'systematic, consistent and simultaneous measurements of physical, chemical, biological, and human-effects variables over time and at specified locations.' In theory, by monitoring a wide range of variables at long-term sites it is possible to gain an understanding of how ecosystems function and respond to change (Bricker and Ruggiero 1998). Coupling monitoring with research and modeling may make it possible to predict what will happen in the future and, if necessary, devise appropriate response strategies.

Ecological monitoring is important for a variety of reasons:

First, ecological monitoring provides important understanding and insights into long-term ecological phenomena and the functioning of complex ecosystems across park boundaries.

Secondly, ecological monitoring objectively evaluates whether mandates and policies of protecting park natural resources are being achieved. One of the major shortcomings of most of natural resources management and conservation plans has been the absence of a comprehensive ecological monitoring program (Kremen et. al 1998).

Thirdly, ecological monitoring can detect and evaluate the long-term adverse effects of human activities on park ecosystems. This is particularly important because there is often a lag between a disturbance event and a subsequent response.

Fourthly, information that flows from ecological monitoring can play a pivotal role in educating stakeholders, park visitors and the general public, and garnering support for the protection of park ecosystems and natural ecological processes.

B. NPS Policies and Mandates that link Monitoring and Management of Parks: Who is Interested in the information provided by monitoring and why?

The enabling legislation establishing the National Park Service and its individual park units clearly mandates, as the primary objective, the protection, preservation and conservation of park resources, in perpetuity for the use and enjoyment of future generations (NPS 1980). National Park Service policy and recent legislation National Parks Omnibus Management Act of 1998: Title II-National ... requires that park managers know the condition of natural resources under their stewardship and monitor long-term trends in those resources in order to fulfill the NPS mission of conserving parks unimpaired The following laws and management policies provide the mandate for inventorying and monitoring in national parks:

National Park managers are directed by federal law and National Park Service policies and guidance to know the status and trends in the condition of natural resources under their stewardship in order to fulfill the NPS mission of conserving parks unimpaired. The mission of the National Park Service (National Park Service Organic Act, 1916) is:

> "*...to promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified by such means and*

measures as conform to the fundamental purposes of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations".

Congress strengthened the National Park Service's protective function, and provided language important to recent decisions about resource impairment, when it amended the Organic Act in 1978 to state that "the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established…".

More recently, the National Parks Omnibus Management Act of 1998 established the framework for fully integrating natural resource monitoring and other science activities into the management processes of the National Park System. The Act charges the Secretary of the Interior to "continually improve the ability of the National Park Service to provide state-of-the-art management, protection, and interpretation of and research on the resources of the National Park System", and to "… assure the full and proper utilization of the results of scientific studies for park management decisions." Section 5934 of the Act requires the Secretary of the Interior to develop a program of "inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources."

Congress reinforced the message of the National Parks Omnibus Management Act of 1998 in its text of the FY 2000 Appropriations bill:

> *"The Committee applauds the Service for recognizing that the preservation of the diverse natural elements and the great scenic beauty of America's national parks and other units should be as high a priority in the Service as providing visitor services. A major part of protecting those resources is knowing what they are, where they are, how they interact with their environment and what condition they are in. This involves a serious commitment from the leadership of the National Park Service to insist that the superintendents carry out a systematic, consistent, professional inventory and monitoring program, along with other scientific activities, that is regularly updated to ensure that the Service makes sound resource decisions based on sound scientific data."*

The 2001 NPS Management Policies updated previous policy and specifically directed the Service to inventory and monitor natural systems:

> *"Natural systems in the national park system, and the human influences upon them, will be monitored to detect change. The Service will use the results of monitoring and research to understand the detected change and to develop appropriate management actions".*

Further, *"The Service will:*

- *Identify, acquire, and interpret needed inventory, monitoring, and research, including applicable traditional knowledge, to obtain information and data that will help park managers accomplish park management objectives provided for in law and planning documents.*
- *Define, assemble, and synthesize comprehensive baseline inventory data describing the natural resources under its stewardship, and identify the processes that influence those resources.*
- *Use qualitative and quantitative techniques to monitor key aspects of resources and processes at regular intervals.*
- *Analyze the resulting information to detect or predict changes, including interrelationships with visitor carrying capacities, that may require management intervention, and to provide reference points for comparison with other environments and time frames.*
- *Use the resulting information to maintain-and, where necessary, restore-the integrity of natural systems" (2001 NPS Management Policies).*

Additional statutes provide legal direction for expending funds to determine the condition of natural resources in parks and specifically guide the natural resource management of network parks, including:

- Taylor Grazing Act 1934;
- Fish and Wildlife Coordination Acts, 1958 and 1980;
- Wilderness Act 1964;
- National Historic Preservation Act 1966;
- National Environmental Policy Act of 1969
- Clean Water Act 1972, amended 1977, 1987;
- Endangered Species Act 1973, amended 1982
- Migratory Bird Treaty Act, 1974;
- Forest and Rangeland Renewable Resources Planning Acts of 1974 and 1976
- Mining in the Parks Act 1976;
- American Indian Religious Freedom Act 1978;
- Archaeological Resources Protection Act 1979;
- Federal Cave Resources Protection Act 1988;
- Clean Air Act, amended 1990;

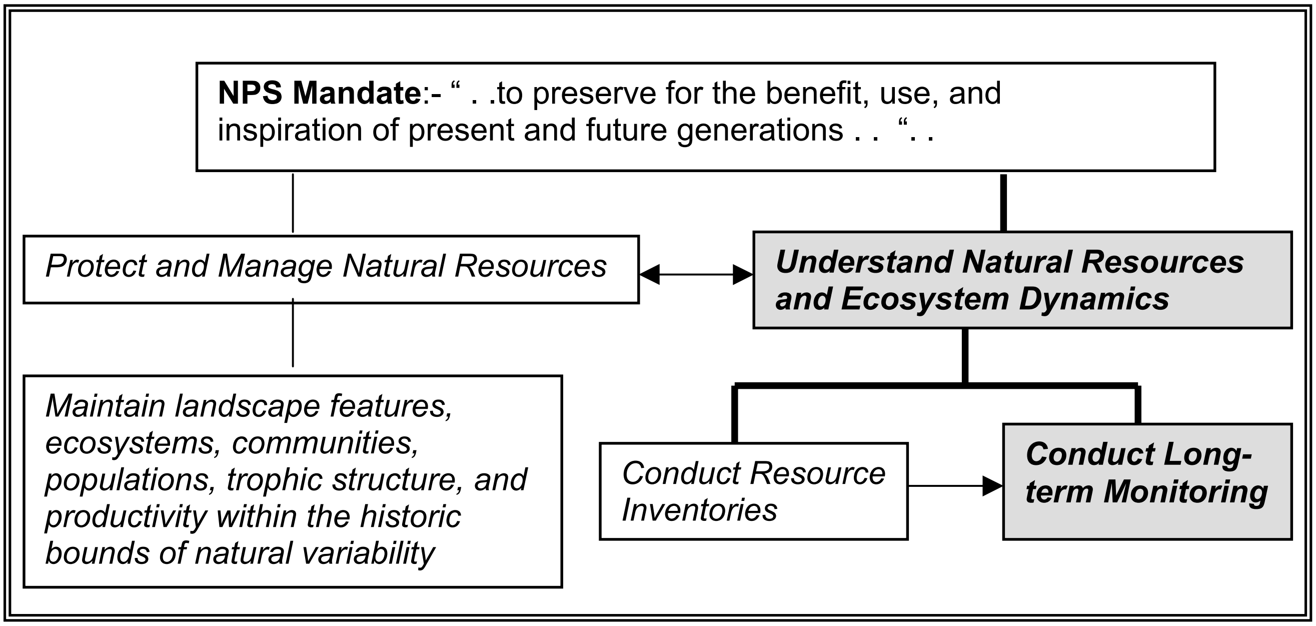


Figure 1. Relationship between park mandates, protecting resources, and long-term monitoring

1) Some Applications of Information Gained From Monitoring

The most widely identified application of monitoring information is that of enabling managers to make better informed management decisions (White and Bratton 1980, Croze 1982, Jones 1986, Davis 1989, Quinn and van Riper 1990). For example, the effects of park visitors trampling riparian vegetation can be monitored to determine whether changes in visitor management strategies are needed to prevent streambank erosion and deterioration of water quality.

Broad-scale ecosystem monitoring, as proposed in this plan, builds a holistic view of park landscapes and provides a tool for addressing issues that occur at multiple sites within a park or multiple parks within a network, rather than site-specific problems to be addressed individually. From this holistic view, managers can develop general principles and guidelines that can be applied broadly to this type of issue or problem. For example, understanding how coastal shorelines are responding to sea level rise might allow managers to predict the fate of public-use cabins, vessel mooring buoys, biological, or cultural resources and develop a network-wide strategy for taking a specific action or planning additional monitoring.

In large wilderness park units, an important application of monitoring information is simply to gain insight into "how complex park ecosystems work" (Croze 1982). By gathering data over long periods of time, correlations between different attributes (such as predator and prey populations) become apparent, and a better general understanding of the ecosystem is obtained. In turn, this knowledge may support future decisions concerning existing or proposed harvest levels on a species.

Similarly, some authors suggest that it is important to document changes just for the sake of familiarity with the resources (Halvorson 1984, Croze 1982). The responsibility of resource managers includes being aware of changes in resources under their stewardship even if no specific management decisions or actions are involved. For example, a park may want to monitor vegetation succession in areas where glaciers are retreating even if no active management of the vegetation is contemplated.

Another use of monitoring information is to convince others to make decisions benefiting national parks (Johnson and Bratton 1978, Croze 1982). Some aspects of monitoring may focus on documenting specific internal or external threats. For example, parks and neighboring coastal landowners may monitor concentrations of hydrocarbons in benthic invertebrates to document the effects of off-shore oil and gas activities on nearshore intertidal communities. In this case, the information may be used to convince local governments, native corporations, industries, or even courts of law to make decisions benefiting national parks.

Monitoring sensitive species, wilderness-dependent species, or entire communities in pristine wilderness park units can provide park managers, stakeholders, and the public with a kind of "canary in the mine" -- an early warning of the effects of human activities before they are noticeable in less pristine areas (Davis 1989, Wiersma 1984). For example, the effects of long-range transport and deposition of air pollutants are most easily recognized in locations free from local sources.

Finally, a monitoring program can provide basic background information that is needed by park researchers, public information offices, interpreters, and those wanting to know a little more about the area around them (Johnson and Bratton 1978). Data such as basic weather information, plant phenology, and records of major events such as volcanic eruptions and landslides are useful to those working or visiting in the parks.

C. Southwest Alaska Network-- Environmental Setting and Park-Specific Mandates: What physical and biological features make these Park Units special?

The Southwest Alaska Network consists of five units of the National Park Service (Figure 2). Katmai National Park and Preserve (6,409 mi^2), Alagnak Wild River (48 mi^2), Aniakchak National Monument and Preserve (942 mi^2), and Lake Clark National Park and Preserve (6,254 mi^2) are managed as one administrative unit by a superintendent based in Anchorage and support staff based in King Salmon and Port Alsworth. Kenai Fjords National Park (1,094 mi^2) is managed by a superintendent and support staff based in Seward. Collectively these units comprise 9.4 million acres, 11.6% of the land managed by the National Park Service, or 2% of the Alaska land mass and include a diversity of geologic features, ecosystems, wildlife, and climate conditions that are equaled few places in North American (Appendix A).

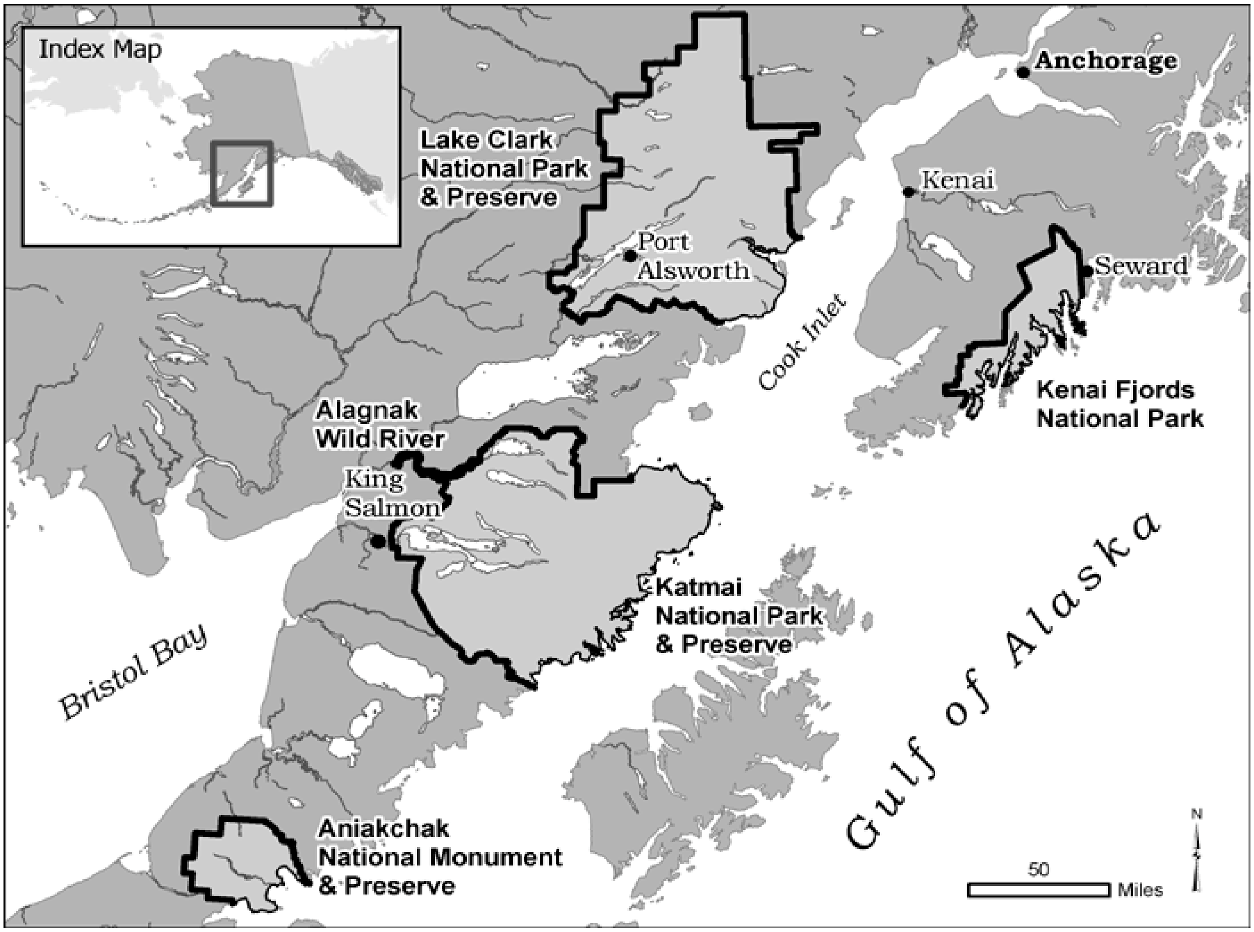


Figure 2. National Park Units of the Southwest Alaska Network.

1) Dynamic Landform Processes and Pattern-

From steep glaciated fjords in the east to smoldering volcanoes on the western horizon, SWAN parks occur in one of the most geologically active regions of the continent. The network is located on an active tectonic shelf of the Pacific Ocean Plate in one of the most seismically erratic regions of the United States. During the 1964 earthquake lands within the Kenai Fjords subsided three to six vertical feet while in Lake Clark and Katmai coastal lands rose. There are at least seventeen "active" volcanoes in the network and Katmai National Monument was created to preserve the famed Valley of Ten Thousand Smokes, a spectacular forty square mile, 100 to 700 foot deep, pyroclastic ash flow deposited by the 1912 eruption of Novarupta Volcano. Aniakchak National Monument was created in recognition of the unique geological significance of its 6-mile-wide, 2,000-foot-deep caldera formed by the collapse of a 7,000-foot mountain.

Approximately one-fifth of the landmass of this network is covered by ice or permanent snowfields. Valley and tidewater glaciers radiate from massive snowfields along the coastal mountains of the 3 northernmost parks. Much of Kenai Fjords is a landscape of ice and tidewater glaciers formed by the forces of the Harding and Grewingk-Yalik icefields as they plunge into the sea. Ten of the thirty-four tidewater and hanging glaciers that emanate from Harding Icefield are included within the park.

Volcanic eruptions, tectonic forces, and glacial processes combine to make this network an important laboratory for both geologic research and long-term ecological studies of how landscapes respond to infrequent, large-scale disturbances. For example, a unique opportunity exists to observe pattern and relative timing of ice retreat, primary and secondary plant succession, pattern of animal colonization, and evolutionary processes.

> ***Mandate: <u>Aniakchak National Monument and Preserve</u>-*** *"To maintain the caldera and its associated volcanic features and landscape, including the Aniakchak River and other lakes and streams, in their natural state; To protect habitat for, and populations of, fish and wildlife, including, but not limited to, brown/grizzly bears, moose, caribou, sea lions, seals, and other marine mammals, geese, swans, and other waterfowl….." (ANILCA):*

2) Marine Coastline-

SWAN parks contain approximately one-third of the marine coastline in the National Park System. This coastline spans 1,200 miles in the Northern Gulf of Alaska from the heavily glaciated Kenai Fords to unglaciated Aniakchak on the Alaska Peninsula. The networks varied coastlines, numerous freshwater sources, and diverse geomorphology generate many combinations of physical factors, creating a microcosm of the Northern Gulf of Alaska. Kenai Fjord's rocky headlands with extreme wave exposure are contrasted with protected low energy beaches and broad intertidal flats at Katmai and Lake Clark.

SWAN coastal waters in the northern Gulf of Alaska lie in one of the most biologically productive nearshore ecosystems in the world (Sambrotto and Lorenzen 1986). What makes this region so productive? In the Gulf of Alaska, high tides, frequent storms, and persistent currents stimulate strong, vertical mixing along the continental shelf. Mixing brings essential nutrients from the water column to the surface euphotic zone, where they support phytoplankton growth (Hood and Zimmerman 1986). Nutrient rich water upwelled by the Alaska Coastal Current affects the entire network coastline and contributes to high productivity (Burbank 1977, Lees 1977).

> ***Mandate: <u>Kenai Fjords National Park</u>-*** *"To maintain unimpaired the scenic and environmental integrity of the Harding Icefield, its outflowing glaciers, and coastal fjords and islands in their natural state; and to protect seals, sea lions, other marine mammals, and marine and other birds and to maintain their hauling and breeding areas in their natural state, free of human activity which is disruptive to their natural processes." (ANILCA)*

Some key ecological features of the Network coastline include: 1) sheltered salt marshes and tidal flats that support lush brackish vegetation, large populations of benthic organisms, and serve as important feeding and resting areas for brown bears (Ursus arctos), shorebirds, and fish; 2) cliffs, headlands, and islands that support seabird rookeries and marine mammal haulouts; 3) eelgrass and kelp beds that provide herring spawning areas and a nursery substrate that supports the base of the nearshore food chain; and 4) tidally-influenced coastal freshwater streams that support wild stocks of anadromous salmon.

3) Aquatic systems, Anadromous Fish, and Ecological Interrelationships- Wild anadromous fish link the ocean, fresh water, and land in important functional ways, supporting a complex food web that crosses the land-water interface. The interrelationship between sockeye salmon, brown bears, and the structure and function of both aquatic and terrestrial ecosystems is a flagship ecological resource of the network, and of national and international significance.

> ***Mandate: <u>Lake Clark National Park and Preserve</u>-*** *"To protect the watershed necessary for the perpetuation of the red salmon fishery in Bristol Bay; To maintain unimpaired the scenic beauty and quality of portions of the Alaska Range and the Aleutian Range, including volcanoes, glaciers, wild rivers, lakes, waterfalls, and alpine meadows in their natural state; To protect habitats for and populations of fish and wildlife, including, but not limited to caribou, Dall sheep, brown/grizzly bears, bald eagles, and peregrine falcons." (ANILCA)*

Network Parks contains some of the largest and most "pristine" freshwater resources in the National Park System. This includes the two largest lakes, Naknek Lake and Lake Clark, numerous multilake systems, and thousands of miles of rivers including five designated "Wild Rivers." Approximately 432,000 acres (12%) of Katmai is occupied by surface water. Aquatic systems in the western portions of Katmai and Lake Clark are so extensive that they form the template upon which biological systems at all levels are organized.

Aquatic systems in the network are pristine in the sense that: a) natural watershed processes are operating including disturbances such as flood events and seasonal changes in flow; b) water quality is unimpaired; and c) aquatic fauna diversity and productivity vary naturally over both time and space. Aquatic and terrestrial animals have likely had a very long, and probably co-evolutionary, relationship with salmon in each of these parks. For example, Johnson et al. (1997) examined the relationships between the Pacific salmon and wildlife in Washington and Oregon and found that of 138 wildlife species, 88 were characterized as having a routine relationship (consistent and recurrent) with salmon. The magnitude of salmon-wildlife-ecosystem relationships calls attention to the consequences of loss or severe depletion of anadromous fish stocks and the role that long-term monitoring can play in tracking overall condition and changes in this ecological relationship.

4) Wilderness-dependent Large Mammal Species and Species Interactions-
Despite hunting and other human activities, all parks in this network possess intact naturally functioning terrestrial ecosystems with their historic complement of species, including large apex carnivores and predator-predator predator-prey interactions. Intact functioning ecosystems with historic levels of biodiversity are becoming extremely rare globally and are a resource of great value locally and internationally.

Some key wilderness dependent mammals in SWAN are wolverines (Gulo gulo), brown bears (Ursus arctos horribilis), wolves (Canis lupus), and lynx (Lynx rufus). These species do not require wilderness habitats per se, but because they require wilderness to avoid conflicts with humans and to avoid human-caused mortality. They also depend on free roaming naturally cycling prey populations. Some key wilderness-dependent interactions include wolf-ungulate, brown bear-ungulate, carnivore-carnivore, predator-scavenger, and cyclic lynx-snowshoe hare (*Lepus americanus)* interactions.

> ***Mandate: Katmai National Park and Preserve-*** *"for the protection of the ecological and other scientific values of Naknek lake and the existing monument….." "To protect habitats for, and populations of, fish and wildlife, including, but not limited to, high concentrations of brown/grizzly bears and their denning areas; to maintain unimpaired the water habitat for significant salmon populations; and to protect scenic, geological, cultural, and recreational features." (Antiquities Act)*

Davis and Halvorson (1988) considered national park ecosystems to be "miner's canaries" and nowhere is this concept more appropriate than when applied to wilderness-dependent species (Peek 1999). Because they are sensitive to human disturbance and need large tracks of wild land or wilderness to survive, their status signals impending environmental change across broad geographic areas. For example, wolverines are a classic wilderness-dependent species because they require large spatial areas with a full array of seasonal habitats, intact populations of prey, larger apex predators that provide scavenging opportunities, and refugia from human influences. Banci (1994) found that persistence of wolverine in southwestern Alberta is due entirely to the presence of large refugia, in the form of national parks. As wild ecosystems are progressively compromised by a variety of human activities such as mining, logging, recreation, and settlement, what is left becomes increasingly valuable as laboratories of natural ecological processes.

5) Ecoregion and Biological Diversity-
Southwest Alaska parks are a place 'where land and water meet.' Lake Clark National Park is often called "one park, four Alaska's" referring to the diversity of landscapes relative to area. Although not as dramatic, this feature is shared by each of the network parks which collectively span 3 Alaskan climatic zones and 11 ecoregions (Appendix F. SWAN Ecoregions Map). This landscape diversity is a product of the interaction of climate, terrain, and tectonics. Network parks showcase

> ***Mandate: Alagnak National Wild River-*** *"To protect and enhance the values which caused it to be included in said system…." These values are the river's outstandingly remarkable scenic, fish and wildlife, and recreation attributes. (ANILCA)*

the major stages of Alaska's history, including significant ongoing geological processes in the development of landforms; and significant ongoing ecological and biological processes in the evolution and development of terrestrial, freshwater, and coastal ecosystems and their biotic communities.

Landscape diversity provides the template for relatively high biological diversity. Consequently, this region of Alaska is a crossroad for many species of plants and animals. Peninsulas have been conceptualized as resembling a chain of islands upon which species may "hop" in order to disperse from mainland populations to the distal ends of the peninsula (Noss and Cooperrider 1994). Numerous species of animals such as Dall sheep, black bear, and Trumpeter Swans and plant communities such as coastal rainforest and boreal forest reach the limits of their state-wide range in Southwest network parks.

Climate change and its influence on the distribution of plants and animals in this network have broad implications for long-term monitoring. The geographic ranges of most plant and animal species are limited by climatic factors, including temperature, precipitation, soil moisture, humidity, and wind. Peninsula landmasses are likely to respond to climate change more rapidly and severely than insular areas because of a greater coast/interior ratio (Suffling and Scott 2002). Colonization by new species, distribution shifts by existing species, or changes in life cycle patterns such as the timing of migrations, all have implications for park management and resource protection.

D. Formation of the Network and Approach to Planning a Monitoring Program

The first step in developing a long-term monitoring program is to articulate clearly the management goals and objectives of the parks and the network of parks in concert with regional and Servicewide goals and objectives. Park-specific goals and objectives will be based on factors such as the park's enabling legislation, legal mandates for monitoring endangered species and other resources, planning documents such as the General Management Plan or Resource Management Plan, and input from park managers and scientists regarding important park resources and the physical and biological drivers affecting those resources. The information needed to formulate these goals and objectives is a large part of the Phase I planning (Table 1) and is outlined in the Recommended Approach for Developing a Network Monitoring Program.

The Southwest Alaska network received initial funding for biological inventories in FY2001 and vital signs monitoring-Phase I funding in FY2002. A biological inventory coordinator was staffed in May 2001 and network inventory and monitoring coordinator in November 2001 (Table 2). Subsequent staff additions included a Data Manager in March 2002 and an Aquatic Ecologist in November 2002. Initial planning efforts began in January and February 2002 with the formation of a Board of Directors and a Technical Committee. Both the Board and Technical Committee developed and adopted a Charter.

Table 1. Overall timeline for the Southwest Alaska Network to complete the entire 3-phase planning and design process for developing a monitoring plan.

	FY01 Oct-Mar	FY01 Apr-Sep	FY02 Oct-Mar	FY02 Apr-Sep	FY03 Oct-Mar	FY03 Apr-Sep	FY04 Oct-Mar	FY04 Apr-Sep	FY05 Oct-Mar
Data gathering, internal scoping									
Inventories to Support Monitoring									
Scoping Workshops									
Conceptual Modeling									
Indicator Prioritization and Selection									
Protocol Development, Monitoring Design									
Monitoring Plan Due Dates Phase 1, 2, 3					Phase 1 Oct 03		Phase 2 Oct 04		Phase 3 Dec 05

The three-member SWAN Board of Directors consists of 2 superintendents representing the Park Units and the Alaska Regional Inventory and Monitoring (I&M) Coordinator. The Southwest Alaska Network I&M Coordinator and the Alaska Regional Science Advisor serve as non-voting members of the Board. The nine-member Technical Committee consists of the Chiefs of Resource Management and one natural resource scientist (two representatives) from LACL, KATM/ANIA/ALAG, and KEFJ; and the SWAN I&M Coordinator (chairman). The committee also includes three advisors that do not directly work for the parks, NPS Alaska Region I&M Coordinator, NPS-AKSO Regional ecologist, and a USGS-Alaska Science Center fish and wildlife biologist that serves as a liaison to NPS for long-term monitoring.

Table 2. Summary of events in the organisation of the Southwest Alaska Network and planning during Phase 1.

Date	Event
2001	
November	Network Coordinator entered on duty
2002	
January	Board of Directors established, first board meeting held, BOD charter approved.
February	Technical Committee established, TC charter approved, data manager entered on duty
March-May	Technical Committee meetings held to develop strategy for Phase I planning
June-July	Preparation for coastal scoping workshop
August	Coastal nearshore scoping workshop
September	Preparation for freshwater scoping workshop
November	Freshwater scoping workshop, aquatic ecologist (term) entered on duty
December	Prepare freshwater scoping workshop summary
2003	

Date	Event
January-February	Development of baseline survey and pilot project study plans
March	Preparation for terrestrial scoping workshops
April	Terrestrial vegetation and fauna scoping workshop
June-August	Phase I report preparation

During March-May 2002, the Technical Committee held a series of meeting to develop a strategy for breaking the three phase planning process into manageable pieces that could be tackled sequentially.   Considerations in developing this strategy were: 1) the relatively small size of the natural resources staff in the network parks (at the onset of planning the combined natural resources staff of the 3 administrative units numbered seven); 2) logistical challenges of meeting as a group because park staff are based in 3 different rural Alaska locations; and 3) a desire by Technical Committee members to collectively participate as a single team throughout the planning process.

In light of these considerations, the Technical Committee elected to use a series of mini-scoping workshops to review and discuss the current state of knowledge concerning park ecosystems, resource protection issues, and potential options for monitoring. The objectives for these workshops were to: 1) review/refine conceptual ecosystem models and monitoring questions; 2) identify drivers of change and why it is important to understand them; and 3) identify candidate attributes to monitor that provide reliable signals about ecosystem condition. Workshops were attended by Technical Committee, NPS staff from other networks and the Alaska Regional Office, and scientists from universities, State of Alaska agencies, and other federal agencies.

Most workshops had a community or ecosystem focus and workshops were ordered in sequence ocean⇒ freshwater⇒ terrestrial (Table 3). The cascading sequence allowed many of the same participants to “flow” with the process and the workshop summaries created a growing base of information that enhanced efficiency of successive workshops and integration of components.   Pre-workshop preparation involved assembling extensive background material on network parks and developing draft objectives and potential monitoring questions. This background material or “notebook” was mailed to participant’s one month before each workshop to familiarize them with the landscape and stimulate more discussion and comment (Appendix E: coastal, freshwater, vegetation, fauna).

Table 3. Scoping workshops held in 2002-2003 to identify ecosystem drivers and other agents of change, resource management and scientific issues, and monitoring options for parks in the Southwest Alaska Network.

DATE/PLACE	***PARTICIPANTS[1]***	***SUBJECT***	***PURPOSE***
May 2, 2003 in Anchorage, AK	Network Park Staff, Subject Matter Expert(s): Karen Oakley USGS	Network Landscape Ecosystems	Identify: Dominant Resource Management Issues; Focus Areas for Long-term Monitoring, Physical and Human-related Agents of Change, and Landscape Sub-components to be addressed by Subsequent Workshops
August 26-28, 2002 at Kenai Fjords National Park	Network Park Staff, Subject Matter Expert(s): Charles Peterson, Univ. North Carolina; Carl Schoch, Kachemak Bay Research Reserve-ADF&G; Vernon Byrd, Alaska Maritime NWR-USFWS; Karen Oakley USGS ; Peter Armato NPS	Marine-Coastal Nearshore Ecosystems	Review Modify Ecosystem Conceptual Models; Identify Ecosystem Drivers of Change; Identify Key Resources, their Ecological Importance, and how they are effected by Drivers of Change; Identify Candidate Resources and Attributes for Monitoring
November, 4-6, 2002 at Cooper Landing, AK	Network Park Staff, Subject Matter Expert(s): John Magnuson, Univ. Wisconsin; Robert Stallard, USGS-WRD, Joe Margraf, Univ. Alaska-Fairbanks; Jim Larson, USFWS: Phil North, EPA; Karen Oakley USGS ; Nancy Deschu NPS	Freshwater Ecosystems	Review Modify Ecosystem Conceptual Models; Identify Ecosystem Drivers of Change; Identify Key Resources, their Ecological Importance, and how they are effected by Drivers of Change; Identify Candidate Resources and Attributes for Monitoring
December 12, 2002 in Anchorage, AK	Network Park Staff, Subject Matter Experts: Michael Shephard, USFS; Karen Oakley USGS	Physical Landscape Drivers	Review Modify Landscape Conceptual Models; Identify Key Physical Drivers of Change and how they are Manifested as Gradients of Temperature and Precipitation; Identify Catastrophic Disturbance Events
April 16-17, 2003 in Anchorage, AK	Network Park Staff, Subject Matter Expert(s): Robert Gill Jr. USGS; David Duffy, Pacific CESU; Rob DeVelice, USFS; Gerald Tande, ANHP; Ed Berg, USFWS; Torre Jorgenson, Alaska Biol. Research; Karen Oakley USGS; Terry DeBruyn NPS	Terrestrial Ecosystems-Fauna and Flora	Review Modify Ecosystem Conceptual Models; Identify Ecosystem Drivers of Change; Identify Key Resources, their Ecological Importance, and how they are effected by Drivers of Change; Identify Candidate Resources and Attributes for Monitoring

[1.] ADF&G- Alaska Department of Fish and Game; USFWS- U.S. Fish and Wildlife Service; USGS- U.S. Geological Survey; USFS-U.S. Forest Service; EPA- Environmental Protection Agency; CESU- Cooperative Ecosystems Study Unit; ANHP- Alaska Natural Heritage Program

Scoping workshop discussions were recorded and compiled into a workshop summary report. Summary reports were sent to participants and posted on the network web site (Appendix F: coastal, freshwater, vegetation, fauna). Workshop notebooks and summary reports were also circulated for technical review and comment by scientists that did not attend the workshop (Table 4). Review comments were not used to revise the summaries but added as an attachment and will be considered by the Technical Committee during Phase II planning.

Table 4. Technical reviewers of scoping workshop summaries, Southwest Alaska Network.

Technical Reviewer and Affiliation(s)	Area(s) of Expertise
Ginny L. Eckert Assistant Professor of Biology University of Alaska, Southeast School of Fisheries and Ocean Sciences	Marine intertidal ecology and monitoring, population dynamics of benthic marine invertebrates
Mark W. Oswood Professor of Zoology University of Alaska- Inst of Arctic Biology Bonanza Creek LTER	Freshwater ecology, especially of rivers and streams; limnology; entomology; biodiversity of aquatic invertebrates
Andrea Woodward Research Ecologist USGS FRESC Olympic Field Station Seattle, WA	Development of long-term ecological monitoring; plant-animal interactions; effects of climate change on subalpine plant communities
Michael Shephard Ecologist US Forest Service State and Private Forestry	Community ecology, dynamics of coastal rainforests, ecoregion mapping, invasive exotic plants
John N. Schoen Senior Scientist National Audubon Society - Alaska State Office Affiliate Professor of Wildlife Biology University of Alaska	Large mammal population dynamics, forest wildlife habitat relationships, conservation of landscape biodiversity

The network's strategy for water quality monitoring [funded by the NPS Water Resources Division (WRD)] is to fully integrate the design and implementation of water quality monitoring with the network-based vital signs monitoring. Issues effecting water quality, role of water quality monitoring in an integrated ecosystem context, WRD core variables, and other water quality parameters were discussed at the coastal, freshwater and other scoping workshops.

"Data mining" and literature synthesis for both water quality and vital signs monitoring began during the Phase I and will continue through the completion of the final monitoring plan. A survey of current and historical monitoring efforts within network parks was conducted to identify opportunities to continue, modify, or expand existing programs (Appendix C). This survey involved compiling internal documents housed at network parks and the Alaska NPS Support Office. Each parks bibliographic catalog was updated and metadata created for all existing data. An I&M bibliography was also developed in coordination with the Alaska Resources Library and Information Service (ARLIS) and Alaska's Cooperatively Implemented Information Management System

(CIIMMS). Both of these services provide web-based tools that help users find and share information about Alaska's natural resources.

To identify partnership opportunities and benefit from monitoring efforts being conducted by other federal and state agencies, we reviewed global, national, regional, and local monitoring efforts that may be relevant to natural resource monitoring in our network. A portion of this survey was accomplished through the use of a questionnaire that was mailed to neighboring land management agencies and scientists conducting research or monitoring in southwestern Alaska. We compiled information into databases of existing and planned research and monitoring within ecoregions encompassed by the network. Other partnership opportunities were identified during scoping workshops (Appendix D).

E. Conceptual Foundation for Monitoring

The Southwest Alaska Network embodies a vast, diverse, and dynamic landscape that changes over space and time in response to inputs of energy, natural events, and the influence of humans. Monitoring at large geographic scales requires a framework for understanding relationships between components and processes of interacting ecosystems and the human activities that affect them. For example, to understand how Park ecosystems respond to adverse effects arising from human activities, we need to be able to distinguish between what is “normal” and “abnormal” for them. Scientifically sound information on ecosystem status and trends can only be obtained through long-term monitoring. Short-term monitoring provides an incomplete picture because annual fluctuations may reflect variables that cycle over decades such as precipitation patterns, temperature regimes, or predator and prey populations. This is particularly true in subarctic regions such as Alaska where biological processes are relatively slow and intrinsic dynamics of populations are high. In consideration of this, our conceptual foundation provides a guide for monitoring and research.

> *“The Southwest Alaska Network and its surrounding landmass, glaciers, lakes, rivers, and marine coastline are an interconnected set of ecosystems that must be monitored as an integrated whole. Within this interconnected whole, at time-scales of years to decades, we assert that climate, natural disturbance, biotic interactions, and human activities are the most important driving forces in determining ecosystem structure and function. Consequently, our monitoring program must address the interplay of multiple forces, which occur at a variety of spatial and temporal scales, in order to understand the structure and function of network ecosystems.”*

This conceptual foundation forms the basis for a program that will be:

- **Ecologically-based** and **issues-oriented** with emphasis on assessing long-term and cumulative effects rather than short-term and isolated effects
- **Interdisciplinary** and incorporate disciplines of biology, hydrology, geomorphology, and landscape ecology and at multiple scales (e.g., coarser-grained network-scale, and finer-grained park-scale).
- **Integrative** and blends a "top-down" approach for characterizing ecological systems, with a "bottom-up" understanding of ecosystem processes and functions

1) ***Ecologically-based Monitoring**: Why is it important to have a landscape perspective when designing a long-term monitoring program?*

The network landscape is a heterogeneous land area composed of interacting ecosystems that differ structurally in the distribution of species, communities, energy, and materials. Among the many ways that this is important for park managers is that the kinds of organisms that can exist (including their movement patterns, interactions, and influence over ecosystem processes) are constrained by the sizes, shapes, and patterns of interspersion of habitat across this landscape. Landscape ecology is a science that explores how this heterogeneous combination of ecosystem attributes is structured, functions, and changes (Forman and Godron 1986). Four principles of landscape ecology have particular importance for long-term monitoring in large Alaskan National Parks. These ecological principles deal with time, place, disturbance, and species.

a) Time Principle-

Ecological processes function at many time scales, some long, some short; and ecosystems change through time. The time principle has several important implications for monitoring. First, the current composition, structure, and function of park ecosystems are, in part, a consequence of historical events or conditions that occurred decades to centuries before. Second, the full ecological effects of human activities often are not seen for many years because of the time it takes for a given action to propagate through components of the system. Finally, the imprint of natural disturbance or land use may persist on the landscape for a long time, constraining processes or species occurrence and abundance for decades or centuries (Dale et al., 2000).

> *'Because we are unable to directly sense slow changes,,, process acting over decades are hidden and reside in "the invisible present.' Magnuson (1990)*

We need to better understand how the temporal dynamics of landscape change in parks affects ecological structure and processes. Short-term ecological events that we see every day often have their origins in transient, rare, slow or subtle processes. Similarly, ecosystem response to natural and human-induced events may be cyclical, directional, episodic or catastrophic. It is extremely difficult for humans to sense change occurring over decades. Magnuson (1990) coined the term "the invisible present" to refer to the loss of information and tendency for misinterpretation when observations of the present are not placed in appropriate time scales.

In the “invisible present” one finds time scales of the invasion of nonnative plants and animals, bioaccumulation of toxins such as mercury, shifts in metapopulation dynamics of large mammals, and carbon dioxide-induced global climate change. These and other events move too slowly to be appreciated in human time, yet their accumulation results in real change over decades. In subarctic national parks, where biological processes are relatively slow and intrinsic dynamics of populations are high, long-term observations are particularly necessary in order to separate human-induced change from naturally occurring processes.

In the past, natural resources research and management in Alaskan parks has been characterized by short-term (1-3 year) projects and in some cases, frequent staff turnover. Short-term projects or breaches in continuity associated with park staff turnover confound interpretation of annual fluctuations in populations that may reflect such variables as precipitation patterns, temperature regimes, predator populations, or natural cycles. Without long-term records park managers cannot interpret the data they have collected and the "invisible present" persists.

b) Place Principle-

Local climatic, hydrologic, edaphic, and geomorphologic factors as well as biotic interactions strongly affect ecological processes and the abundance and distribution of plants and animals at any one place. Local environmental conditions reflect location along gradients of elevation, temperature, salinity, longitude, and latitude and the multitude of meseoscale physical, chemical, and edaphic factors that vary within these gradients. Hence, a rocky shoreline in Kenai Fjords looks very different and has a different biotic community structure from a rocky shoreline at Lake Clark.

> *‘Even though . . . site-specific trends enhance our ecological insights, they rarely answer many questions of significance about larger … systems,’ (Urquhart et al 1998)*

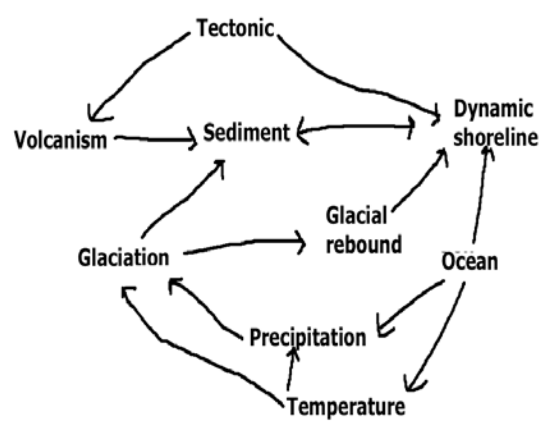
Ecological systems are characterized by multiple drivers acting at multiple scales, complex patterns of spatial variability, thresholds, and non-linearity’s leading to the unexpected. Because ecological processes and responses depend on the spatial context of an observation as well as on its temporal context, the analogy of an ‘invisible place’ as with the invisible present may be appropriate.

Park resource studies are often conducted at small spatial scales due to logistical constraints, costs, and often in response to management issues that are perceived to be “localized.” In field surveys, park biologists often make observations at different “places” with the aim of relating biological response variables (i.e., the abundance of a species, or the structure of an ecological community) to environmental variables. However, being able to take a wide (network) spatial view is important because when the same system is observed at several spatial scales, completely different characteristics in the distribution of organisms can be revealed (Turner et al. 1989).

A reciprocal relationship often exists between landscape structure and composition and ecological processes (Dale et al., 2000). To understand the relation between pattern and process requires that we move beyond simple descriptions at local scales to an assessment at multiple spatial scales. For example, park monitoring programs that target a few parameters or a single entity such as moose distribution or seasonal snowcover, are of limited value for understanding ecological processes, modeling, forecasting change, and developing scenarios to protect park resources. By monitoring a wide range of physical, chemical, and biological variables over time it is possible to gain an understanding of how ecosystems function and respond to change. Additionally, coupling monitoring with research and modeling make it possible to predict what might happen in the future and where possible, devise appropriate management response strategies.

c) Disturbance Principle-

It is imperative that we understand and in some cases quantify the drivers of change in ecological systems. These drivers include both ongoing natural processes, such as weather and interannual climatic variability, and random disturbance events. Understanding the importance of the influence and magnitude of different drivers of change, the collective influence of multiple stresses, the ecological consequences of the changes, and the feedbacks between ecosystems and their physical environments (e.g., composition of the atmosphere or ocean, land use, water quality, sediment flux) are all critical to developing strategies for monitoring.



Disturbances are events that disrupt ecological systems and change landscape pattern. Disturbance has been shown to have many important effects on communities and ecosystems, including enhancing or limiting biological diversity, initiating succession, and creating landscape patterns that influence many ecological factors from movements and densities of organisms to functional attributes of ecosystems (Forman 1995). Disturbance can impose both temporal and spatial heterogeneity on ecological systems.

Major natural disturbances such as earthquakes and volcanic eruptions can have sudden and widespread effects on network parks. The concept of “geoindicators” was developed to describe common earth processes that, in less than a century, are liable to change in magnitude, direction, or rate, enough to affect ecosystem condition and landscape structure (Berger and Iams 1996). Twenty-three of the 27 earth system processes and phenomena named as geoindicators are operative in the Southwest Alaska Network. In addition, human-induced disturbances, such as oil spills, have similar potential to exert sudden, widespread, and long-term change.

d) Species Principle-

Changes in the abundance of species, especially those that influence water and nutrient dynamics, trophic interactions, or disturbance regimes affect the structure and functioning of ecosystems. The term *focal species* is often broadly applied to species that are sensitive to change, signal change, or directly affect ecological systems and landscapes in diverse ways (Frost et al. 1995). “Indicator species” (such as harbor seals) are a focal species because their condition is indicative of the status of a larger functional group of species, reflective of the status of key habitats, or symptomatic of the action of a stressor. “Keystone species” (such as sea otter) have greater effects on ecological processes than would be predicted from their abundance or biomass alone (Power et al. 1996). “Ecological engineers” (such as beaver) alter the habitat and, in doing so, modify the fates and opportunities of other species (Naiman and Rogers 1997). “Umbrella species” (such as brown bear) either have large area requirements or use multiple habitats and thus overlap the habitat requirements of many other species. “Link species” (such as sockeye salmon) exert critical roles in the transfer of matter and energy across trophic levels or provide critical links for energy transfer within complex food webs. Loss of a keystone species or of all species in a major functional group will, by definition, have large ecosystem effects, resulting in dramatic changes in biological diversity, community composition, or total productivity.

The impacts of changes in the abundance and distribution of focal species are diverse. Keystone species affect ecosystems through such processes as competition, mutualism, dispersal, pollination, and disease and by modifying habitats and abiotic factors. For example, brown bear are an important vector for transferring marine nutrients to riparian forests, through dissemination of partially-eaten salmon carcasses and salmon-enriched wastes. To the extent that this process affects productivity and species composition in riparian forests, interactions of salmon and bear may be characterized as keystone interactions controlling the long-term structure and dynamics of riparian communities (Helfield and Naiman 2002)

Because effects of keystones are diverse and involve multiple steps, they are often unexpected despite their fundamental importance to biological diversity and ecosystem dynamics (Paine 1995; Power et al. 1996). The depletion or removal of a keystone species can radically change the diversity and trophic dynamics of a system. Changes in land use that affect keystone species may spread well beyond the boundaries of a land-use unit. Because SWAN parks adjoin state, native and private lands, developments or management actions taken outside parks may create habitats unfavorable to some species and favorable to others, create barriers to movement or dispersal, introduce new predators or competitors, or change existing trophic relationships.

A nonnative species can assume a focal-species role when introduced into an ecosystem and produce numerous effects on the ecosystems. Nonnative species have altered community composition and ecosystem processes via their roles as predators, competitors, pathogens, or vectors of disease and through effects on water balance, productivity, and habitat structure (Drake et al. 1989).

2) Issues-oriented Monitoring: **What are the most important management and scientific issues in the network?**

To achieve success and continued support, long-term monitoring must provide data that are both useful and widely used. The data must be relevant to topics of widespread interest as well as those of specific management concern. Most importantly, the information generated from the monitoring program needs to assist park managers in clarifying and addressing resource protection issues.

As used in this plan, "issues-oriented monitoring" implies that some park resources by virtue of legislative mandate, importance to stakeholders, or risk from a specific threat may receive attention beyond that which would emerge from their ecological position of importance in the landscape. It *does not* imply that monitoring is "issue-driven" and will focus only on a narrow range of issues perceived to be relevant to today's management challenges. The network's monitoring program simply cannot address every resource management interest. Limitations exist because institutional resources devoted to monitoring practices are often constrained by time, finances, and personnel.

The intent of the program is to monitor a select set of ecosystem processes and components that reflect the status of network ecosystems and are relevant to resource protection issues. This information will collectively provide a foundation for understanding the parks and building a more flexible monitoring program. As monitoring proceeds, as data sets are interpreted, as our understanding of ecological processes is enhanced, and as trends are detected, future issues will emerge.

Network park resource protection issues were compiled from former and current management plans, review of published and unpublished literature, and interviews with current and former park staff. Additionally, park resources staff were tasked with developing a list of natural resource management issues or natural resources of special concern (current and anticipated). If known, they also identified the basis for concern by identifying human-caused or environmental threats with the potential to adversely affect park resources. Issues were compiled and summarized under the headings of*: Physical Change; Biological Resources; Pollution; and Human Use* (Appendix B). This matrix was presented and discussed at scoping workshops attended by Regional NPS staff and scientists from other state and federal agencies. A reoccurring theme among issues is a “lack of information.” This is not surprising given the vast size and complexity of the park units, brief history of their resource management programs, and relatively small staff and budget.

Park units in the network share many of the same resource protection issues because of similarity in landscape features, geographic proximity, type and magnitude of public use, and enabling legislation. Most protection issues are linked to human population growth and the many ways that human activities are manifested in affecting ecosystems at the global, regional, network, and park scales. Resource protection issues and concerns of Network parks are discussed under the headings global/regional and network/park human-related issues. Conceptualizing global and local scale human effects is a challenging task because the scales are linked and environmental changes are not evenly distributed over the earth. Global/Regional-scale human-related Issues are manifested as climate change, long-distance air pollution, and demand for fossil fuels and other minerals. Network/park human-related issues are manifested as harvest of plants and animals, recreational use, and private lands development.

a) Global/Regional Scale Issues

Climate change- Projections of human-induced climate changes and evidence of past rapid climatic shifts indicate that patterns of physical and biological change over landscape scales during time frames as short as decades (Hannah et al 2002). Gradual warming over the last 100 years has forced a global movement of animals and plants northward, and it has sped up such perennial spring activities as flowering and egg hatching. In some cases, the shifts have been dramatic. For example, the common murre (*Uria aalge*) breeds 24 days earlier than it did decades ago.

Climate change induced shifts in park ecosystems can be manifested in many different ways, on different temporal and spatial scales. Some anticipated changes in the SWAN include sea-level rise, greater storm intensity and frequency, altered seasonal hydrology, rapid glacial retreat, and shorter duration of lake ice cover. Changes in the physical parameters may not be important in themselves, but may have important effects on biological components of the ecosystem. Because anticipation of changes improves our capacity to protect park resources, it behooves us to increase our understanding of the responses of plants and animals to a changing climate.

Air pollution- Long-distance transport and deposition of air pollutants such as Persistent organic pollutants (POP’s) is an emerging concern in Alaska National Parks. POP’s are man-made organic compounds and highly toxic and they persist in the environment, and bioaccumulate in living organisms. They are able to travel long distances around the globe and migrate to northern climates because of strong south-to-north air flows. The Arctic is, therefore, a potential contaminant storage reservoir and/or sink. Due to a constellation of different factors related to atmospheric patterns, the behavior of contaminants in the environment, temperature, and other factors unique to the Arctic setting, there is cause for concern regarding an increase in levels of contaminants in the Arctic ecosystem.

Various processes remove these contaminants from the atmosphere, oceans and rivers and make them available to plants and animals. Food chains are the major biological pathways for selective uptake, transfer, and sometimes magnification of contaminants by plants and animals. In Alaska contamination has been documented in the marine food web, but whether this contamination extends into the interior of Alaska and encompasses terrestrial animals to the same extent is unknown (Chary 2002).

Oil and other minerals- Extraction, storage, transport, and processing of crude oil is an issue for both coastal and terrestrial resources. The Valdez terminal in Prince William Sound receives approximately 24 billion gallons of oil per year via the Trans-Alaska Pipeline. There are also 15 production platforms operating in Cook Inlet. The Drift River Marine Terminal is a privately owned offshore oil-loading platform in Cook Inlet with an onshore storage facility with a capacity of 1,890,000 barrels crude oil. The Nikiski oil terminal and refinery is located on the Eastern Shore of Cook Inlet. These two oil-loading facilities transfer over 3.3 billion gallons of oil per.

The strong Alaska Coastal Current and high local tidal ranges along the Alaskan coast can quickly transport spills great distances from their source. On March 24, 1989, the tanker vessel *Exxon Valdez* grounded in Prince William Sound, rupturing cargo tanks and spilling approximately 11 million gallons of crude oil into the sea. The coastlines of Kenai Fjords, Katmai, and Aniakchak were oiled by this spill. Smaller spills, leakage from storage tanks, platforms, submerged pipelines and ballast water discharge in Upper Cook Inlet are a chronic source of contamination. The water resources of network parks are also threatened by the potential exploration and development of oil and gas in Lower Cook Inlet and Shelikof Strait under the Outer Continental Shelf program.

b) Network/Park Scale Issues

A concept that is particularly useful for viewing the protection concerns related to near-field human activities in the network is the "*nibbling effect*" (Forbes et al 2001). This concept maintains that a slow but essentially permanent change in ecosystem structure, components, and processes occurs from many seemingly "insignificant" human-related perturbations. Examples of *nibbling* include the liberalization of sport or subsistence harvest levels for a plant or animal, construction of a new airstrip or commercial lodge on a private inholding within a park, or issuance of 10 new Incidental Business Permits for guided backcountry hiking. Alone each "bite" may appear relatively insignificant but collectively they have a cumulative and synergistic effect. *Nibbling* advances slowly over space and time and often along gradients radiating from population centers such as Port Alsworth, or attractions such as Brooks Camp.

Consumptive harvest of plants and animals by humans- Consumptive uses of plants and animals is an issue common to parks created by the Alaskan National Interest and Lands Conservation Act (ANILCA) because this Act allows for subsistence hunting, trapping, fishing and the harvest of plant material within national parks and preserves by local rural residents. Additionally, sport fishing occurs in parks and preserves and sport hunting occurs in preserves. In national parks and preserves, ANILCA also requires the National Park Service, in cooperation with the Alaska Department of Fish and Game, to manage for "healthy" populations of fish and wildlife species within national preserves, and “natural and healthy” populations in national parks.

Historically, the Alaska Department of Fish and Game managed both sport- and subsistence-harvests of wildlife within network parks. In 1990, however, the State of Alaska was ruled to be out of compliance with the subsistence sections of ANILCA, and responsibilities for managing subsistence harvest of wildlife within national parks were delegated to the parks. Under the current legal situation, the Alaska Board of Game establishes regulations for hunting and fishing seasons, harvest limits, and methods and means for non-federally qualified subsistence users in the national preserves. The Federal Subsistence Board establishes regulations for hunting and fishing seasons and harvest for federally qualified subsistence users in parks and preserves.

Although subsistence users have access to all species that were traditionally harvested, most effort is directed at large terrestrial mammals (moose, caribou, Dall sheep, brown bear), harbor seals, and salmon. Monitoring of the harvest rate and population performance of subsistence fish and wildlife resources is a complex challenge that frequently exceeds the capability of park managers. As a result, relationships between recruitment, annual survival, and harvest rate for many subsistence species are unknown and local overharvest, if it occurs, may go undetected.

In Alaska, the state constitution mandates that state resources be managed for maximum sustained yield. While this philosophy directly contradicts NPS policy, the concept of game naturally cycling between scarcity and abundance is not widely or favorably embraced by rural Alaskans. Of concern in recent years is a growing opinion by subsistence users that parks and preserves should also be managed for maximum sustained yield of fish and game resources. Public proposals for regulatory changes that favor greater harvest of predators such as wolf and brown bear have an underlying objective of increasing ungulate populations.

Recreational Use- Human recreational use presents two resource issues; direct impact to physical resources, plants, and animals from actions such as vehicle use and camping; and 2) indirect impacts such as the disturbance or displacement of wildlife from actions such as aircraft overflights. Human use associated with plant and animal harvest imposes these same issues.

Coastlines, lakeshores and high mountain environments are particularly sensitive to the disturbances caused by recreation use. Vehicle traffic, pedestrian trampling, and campsites can create long-lasting impacts because natural recovery is extremely slow. As visitation increases there is pressure to provide new trails or access opportunities into these large wilderness parks. There is also a very strong push to make these very large wilderness parks more accessible by ground transportation.

Human visitor concentration areas adversely affect animals by behavioral habituation, displacement, and introduction of exotic species. Habituation is a threat to species such as bears that may have to be relocated or killed if they lose instinctive fear of humans. Disturbance adversely affects species such as Black-oystercatchers or Peregrin Falcons if they are displaced from habitat during critical phases of their life cycle such as breeding. "Flightseeing" with both small fixed wing aircraft and helicopters and charterboat tours have increased greatly over the last decade. These activities have the capacity to disturb wildlife over wider regions than fixed-point activities such as camping and fishing.

Human traffic into wilderness enhances the opportunity for exotic plants and animals to reach remote areas of the parks where they could go undetected. Avenues of entry include marine charter vessels that originate in Alaskan harbors that are served by transoceanic cargo ships and floatplanes that originate in commercial floatplane bases such as Lake Hood in Anchorage.

Private land development- All parks in the network contain private land inholdings and border private, state, and native-owned lands (Appendix F. SWAN Land Ownership Map). Inholdings range from 1-160 acre parcels owned by an individual or a single business, to large contiguous parcels (>10,000 acres) that are owned by native regional and village corporations. The network of private inholding arose from ANILCA which "guarantees" access and the promised right of communities, landowners and residents to continue their economic livelihood.

Inholdings are most prevalent in Lake Clark and Kenai Fjords. In Lake Clark National Park and Preserve approximately 617,000 acres are in private or state ownership, or are being adjudicated. This includes approximately 75% of the shoreline of Lake Clark and more than 90% of the park’s Cook Inlet coastline. At Kenai Fjords, private economic development potentially could occur on 42,000 acres of land owned by Port Graham Native Corporation. In some cases, the exact land status is clouded by over-selection, selection by more than one entity, and the incomplete adjudication of many small tract entries and allotments.

Residential subdivision and economic development on private lands within network parks can conflict with the enabling legislation and NPS resource preservation objectives. Developments of greatest concern are logging, mining, and the construction of roads, airstrips, lodges, and private houses. Private land inholdings frequently coincide with areas of great ecological value and sensitivity such as rivers, lakeshores, and coastal estuaries. Consequently, large areas of parkland adjacent to inholding are at risk when development occurs. Most concerns over water quality are imbedded in private lands development.

F. Monitoring Goals and Objectives

The overall goal of natural resource monitoring in parks is to develop scientifically sound information on the current status and long term trends in the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems.

The monitoring program of the Southwest Alaska Network will be designed around the five broad Service-wide goals. However, this network of pristine wilderness parks is a unique resource and offers unique opportunities to learn about ecological systems minimally affected by humans. In recognition of this, service-wide goals 1 and 3 establish the primary framework for the monitoring in SWAN because they emphasize: a) establishing baseline reference conditions representing the current status of park and preserve ecosystems; and b) understanding the range of natural variation in park ecosystems and detecting changes over time.

NPS Service-wide Vital Signs Monitoring Goals

1. Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.

2. Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.

3. *Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.*

4. *Provide data to meet certain legal and congressional mandates related to natural resource protection and visitor enjoyment.*

5. Provide a means of measuring progress towards performance goals

Within coastal, freshwater, and terrestrial ecosystems preliminary monitoring objectives and questions were nested within this framework of understanding ecosystem behavior and detecting change. Specific monitoring questions may be modified or additional questions posed as the list of attributes proposed for monitoring is narrowed during Phase II planning.

Coastal Ecosystem Monitoring Objectives and Questions:

Objective 1. Understand how coastal nearshore ecosystems are structured.

- What is the relative composition of shorezone habitats based on physical morphology (form and material)?
- What are baseline nearshore water quality conditions associated with primary production, including temperature, salinity, dissolved oxygen, pH, nutrients, total suspended solids, chlorophyll-a, and total organic carbon and how are they changing temporally?
- Are there biological hotspots along the network coastline with high species diversity, distinctive habitats, or unique assemblages of pants and animals?

Objective 2. Understand how park and preserve coastal nearshore ecosystems function and change over time.

- How does intertidal community structure (species composition and relative abundance) vary over time and how do these changes relate to major abiotic factors such as salinity, temperature, and sediment grain size?
- How is salt marsh plant species composition changing and are vegetation zones migrating?
- Is the linear distance of tidal sloughs changing per unit area of salt marsh and is the configuration of sloughs changing the number or area of tidal ponds?
- Are toxins ingested by benthic invertebrates transferred up the food chain in a form and concentration that can affect reproduction, growth, or survival of vertebrate consumers of those benthic prey?
- What are annual/decadal patterns of fresh water input along the coastline and how will changes in this pattern effect the supply of nutrients and sediments to the intertidal and subtidal?
- How does the timing, magnitude, duration, and species composition of the spring bloom respond to seasonal and interannual variability in nutrient supply and physical conditions?
- How do populations and productivity of marine mammals such as sea otters or seabirds such as Black-legged Kittiwakes, fluctuate interannually and interdecadally? Does food supply play the main role, or does disease and predation?

<u>Objective 3.</u> Understand how park and preserve coastal nearshore ecosystems are influenced by humans.

- How do changes in composition, size or productivity of seabird colonies vary among parks that are subject to different levels of vessel traffic or commercial activities such as fishing?
- What is the relationship between human activities on or near the shoreline and the abundance and productivity of species such as black oystercatchers that are dependent on the intertidal zone for survival?
- Are there stranded pockets of relatively unweathered interstitial oil from the 1989 Exxon Valdez spill remaining on beaches and are they becoming less oiled over time?

Freshwater Ecosystem Monitoring Objectives & Questions:

Objective 1. Understand ecological relationships and long-term changes in the physical, chemical, and biotic features of large rivers and lakes.

- What are baseline water quality conditions associated with primary production, including dissolved oxygen, pH, nutrients, total suspended solids, chlorophyll-a, and total organic carbon and how are they changing temporally?
- How are the thermal dynamics of large lakes changing in relation to the duration or lack of winter ice cover, changes in seasonal runoff, and storm frequency/intensity?
- Are seasonal discharge regimes of snowmelt rivers shifting? (i.e., higher winter flows and lower spring and summer flows?)

Objective 2. Understand how landscape, oceanic, and atmospheric processes interact with rivers, lakes, and wetlands to affect park resources that are ecological "keystones" or highly valued by stakeholders and visitors.

- How is lake food web structure and production to higher trophic levels changing in response to salmon abundance (marine-derived nutrients)?
- Are declining salmon populations having indirect effects on other organisms that make use of salmon at critical times in their life cycle?
- How is primary productivity and trophic structure of glacially included lakes/rivers responding to lower inputs of glacial flour?
- How is the quality of anadromous fish spawning habitat changing in relation to lake water levels, shoreline development?

Objective 3. Understand the ways humans interact with aquatic ecosystems to affect physical and biotic components.

- Are atmospherically deposited or biotransported pollutants such as methyl mercury accumulating in lake sediments and resident biota and are there geographic gradients in their concentrations?
- Is fish community composition and structure changing in lakes and rivers where sport and subsistence fishing effort and harvest are increasing?

Terrestrial Ecosystem Monitoring Objectives and Questions:

Objective 1. Observe structure and composition of plant communities and their spatial distribution on the landscape.

- How are major vegetation communities distributed across the landscape? Are they spread along gradients of terrain, disturbance, or weather?
- What is the vascular and non-vascular species composition of selected plant communities?
- Do some communities represent regionally or globally important biodiversity? Are there refugia from glacial actions and/or volcanic events that harbor distinctive genetic or biological diversity? Do they serve as seed sources for revegetation?

Objective 2. Document rates and types of change in vegetation in response to environmental factors and human effects, especially plant communities that are ecological keystones, sensitive to change, or highly valued by stakeholders,

- How are vegetation communities changing across the SWAN region in response to the primary environmental drivers of weather, tectonics, large-scale disturbances, and human activities?
- How are periglacial areas revegetating after glacial retreat?
- How and where are forest and tall shrub communities expanding (or receding)? How is this expansion effecting alpine, low shrub communities, and barrens?
- How are forest communities responding to spruce bark beetle infestations?
- Are hydrodynamic changes effecting areal extent or species composition of wetland communities?
- Are lichen communities on wind blown ridges maintaining diversity and productivity?

Objective 3. Understand how vegetation patterns and animal distribution are related to each other, and predict how changes in vegetation affect animals.

- How are caribou migration corridors and wintering areas affecting lichen communities?
- Are there patterns of riparian/terrestrial vegetation community diversity associated with foliar nitrogen (N) from spawning salmon delivered by consumers such as bears and river otters? Are these patterns different from riparian systems where salmon are absent?
- How does beaver activity affect formation and succession of wetlands and surrounding deciduous plant communities?
- How will long-term changes in vegetation community composition influence distribution of large ungulates like moose, Dall Sheep, and mountain goats?

<u>Objective 4.</u> Observe and understand natural variability in the occurrence and distribution of terrestrial fauna species and communities across the landscape.

- What species of birds breed in the network and which species are associated with sensitive habitats such alpine meadows and freshwater wetlands?
- What are landscape-scale patterns of species occurrence, distribution and richness across the network?
- Are there combinations of landscape configuration and local vegetation variables that are associated with different levels of species richness?
- Are species range shifts occurring and are they occurring evenly across different habitats?

<u>Objective 5.</u> Understand how rare or ecologically pivotal species are changing over time and, when possible, the functional consequences of this change on other animals, plants, communities, and ecosystems.

- Does occurrence, distribution, or reproductive performance of salmon consumers such as Bald Eagles and brown bears fluctuate synchronously with cycles of salmon abundance?
- How are beaver populations responding to forest succession and hydrographic changes in the volume of surface water?
- Are their important habitat linkages or wildlife corridors for wide ranging wilderness species such as wolves and brown bears and are they changing due to natural or human-related events?
- Are nonnative species introductions occurring and are they affecting native species or communities?

<u>Objective 6.</u> Document and understand how demographic patterns of animal populations are responding to environmental factors and human effects across spatial and temporal scales.

- Do patterns of coastal brown and black bear occurrence and habitat use change when areas are subjected to a greater range or magnitude of human presence and activities?
- How does hunting (sport and subsistence) and poaching influence natural cycles of animal abundance and are harvests creating local population sinks or altering trophic interactions between large mammalian predators and their prey?
- How are wood frogs responding to changes in climate or habitat variables such as hydrography?
- How are changes in nearshore coastal food resources affecting species like river otter that live in the supratidal but forage in estuaries and the subtidal?